Utilization direction of industrial raw products built-up in power station ash dumps

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Abstract. Nowadays hundreds million tons of ash and slag waste (ASW) is produced in Russia yearly. Large territories are needed in order to store such a big waste volume. Besides, it is necessary to conduct special engineering and ecological work at the design and usage stages of this structure. The goal of the research is to outline acceptable ASW utilization methods accumulated in coal burning power station ash dumps and to determine the order of activities to solve the problem. The research methods: experimental where Kansk-Achinsk and Kuznetsk coals are the object of the research. Besides, review of relevant to the problem literature and normative documentation was done to determine activities order, possible ways and limitations of the problem solving. We elucidated that ASW transportation to depleted coal quarries to restore them is essential to arrange in order to solve the problem of ASW utilization. As to new produced ASW, they should be divided into groups according to application field (mostly in construction). The groups correspond to boiler unit load operation. After coal combustion ash is stored in special places (reservoirs, silos). Therefore modern boiler unit might be seen as a production complex of steam and ash and slag material of an adequate quality.

1 Introduction

Nowadays hundreds million tons of ash and slag waste (ASW) is produced in Russia yearly. Large territories are needed in order to store such a big waste volume. Besides, it is necessary to conduct special engineering and ecological work at the design and usage stages of this structure. New territories withheld from commerce are allocated as ash dumps for ASW are filled.

For instance, about 6 million tons of ASW was stored up in the around 70 hectare territory of Mosenergo JSC thermal power plant (TPP) 22 over the years [1]. Ash dump use demands many problems to be solved: dust release from dry beaches causes air and soil pollution, high-mineralized water filtration through bot-tom soils leads to its mixing with surface and ground water [2].

Ash dumps of many stations, taking in account their age, work over designed lifetime what requires constant build-up of their reservoir capacity. Therefore stations bare the on-going cost of such ash dumps building and modernization. Some stations have two or even

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three ash dumps (for example, it is planned to build ash dump No. 3 in the territory of Kuznetskaya PPT). In situations like this stations are obligated to pay land tax. Today the situation is getting worse due to power industry planned change-over to coal.

2 Survey

By address the problem of utilization first we need to classify all known types of utilization. After literature analysis we set aside the following directions:

- ASW extraction from ash dump followed by accompanied transportation and worked-out coal pit filling, or use in landscape work;
- ASW use in construction (ASW use in the industry is well characterized and found a great use);
- ASW use in farming as a soil desoxidant and other;
- ASW use for some elements recovery;
- Modern approaches to ASW utilization which mostly is in developing stages.

Large scale and variety of ASW types are evident. Actually, if we will raise ash from the rank of waste to the rank of industrial goods, raw material, placed product then ash capture will stop being forced and unprofitable and will turn to normal profitable industrial process [1].

There is a solution to the problem: producing operations which products are materials made of ASW or their components; or products of their deeper reprocessing. However, most ASW use variants are impose stringent requirements to initial stock parameters.

A study of ASW, accumulated at ash dump of a single power station, is needed in order to determine acceptable ways for its utilization. First of all, we are interested in an elementary composition of the waste and its evenness through an ash dump area; then we need to determine physical characteristics (such as fusibility properties, density, granulometric composition, specific surface area and other). Obtained data is a base for studying waste passport and determination ever or not ASW could be used in different utilization cycles. Choice of the final utilization method is made after the study for an environment hazard and radiation hazard class has been completed

Initially ASW transition into thermal power station product is attributed to the material passport preparation and approval in certain ecological organizations. The passport contains information about elementary composition, physic-chemical and other properties. When the passport is put together it is necessary to take into consideration product characteristics dependence on many factors such as: combustion fuel type, way of combustion, furnace conditions, boiler load, fly-ash collector type and other.

As can be seen from the above large-scale survey is needed to be conducted. The survey should result in product characteristics and mentioned above properties chart in their various combinations.

Product properties identification should also comply to target groups. For instance, it is very important to determine fly-ash properties against fresh and mature concrete, concrete physical form [3, 4], concrete production and handling as well as prove-in performance and environment compatibility [5] when the fly-ash is used as a concrete additive. Besides, important to know the difference between substance matter properties (elementary, physical, and mineralogical), material structure properties (ignition losses, particle distribution, and density), and specific properties (effect on concrete properties: filling effect, bearing effect etc.) and user benefits (time and cost saving, safety improvement etc.).

3 Laboratory research

We examined the ash dump and studied coal and ASW samples of power stations which burn Kansk-Achinsk and Kuznetsk coal in an attempt to evaluate ASW usability as an industrial raw material. Bench-marks results are presented in table 1.

The analysis proved there are significant descriptors differences of tested ASW samples from ash dumps. As it was noticed earlier, most industries impose stringent requirements to initial stock parameters and therefore the elucidated ASW cannot be utilized in conventional industries (due to a great unevenness in CaO, CaO_{free}, results determination, ignition losses and other main descriptors which are important for construction industry).

However, “fresh” ash and slag show relative perdurability of tested descriptors which are vary in dependence of boiler loading and some other conditions. As can be seen from the above ash and slag research in dependence of boiler loading might be the basis for properties passport preparation in dependence of its work condition, and modern boiler unit we should recognize as a complex of required quality steam and ash and slag materials (ASM) production. Constant composition and properties, proved by the passport of station production, are marked apart ASM from ASW.

Table 1. Kansk-Achinsk and Kuznetsk coal basin coals comparison.

No	Discription		Kuznetsk coal basin	Kansk-Achinsk and Kuznetsk coal basin, Irsha-Borodinskoe field
1	Grade of fuel		1CC	B2
2	As-received basis	W^p, %	9.0	33.0
3		A^p, %	18.2	6.0
4		$S^p_к + S^p_{ор}$, %	0.3	0.2
5		C^p, %	61.5	43.7
6		H^p, %	3.7	3.0
7		N^p, %	1.5	0.6
8		O^p, %	5.8	13.5
9	Lower calorific value, ccal/kg		5 700	3 740
10	Ash on the dry basis, %		20.0	9.0
11	Maximum humidity, %		--	36.0
12	Maximum ash content, %		25.0	15.0
13	Maximum sulphur content, %		--	0.5
14	Hygroscopic moisture, %		1,6	12.0
15	normalized moisture, %*10^3кг/ккал		1,58	8.82
16	Normalized ash content, %*10^3кг/ккал		3,20	1.61
17	Dry ash free volatile-matter content , %		30,0	48.0
18	Ash fusion point, °C	Initial deformation	1 100-1 500	1 180
19		Weaking initiation	1 240-1 500	1 210
20		Fluid initiation	1 280-1 500	1 230
21	Ash chemical composition on sulphates absent basis	SiO_2, %	60.0	47.0
22		Al_2O_3, %	20.8	13.0
23		TiO_2, %	0.83	--
24		Fe_2O_3, %	10.4	8.0
25		CaO, %	2.9	26.0
26		MgO, %	1.4	5.0
27		K_2O, %	2.61	0.5
28		Na_2O, %	0.6	0.5

That is to say we think that stations ASW utilization should be managed in two directions: first of all accumulated in ash dumps ASW utilization (this ASW show great heterogeneity of chemical and other descriptors); secondly – “fresh” ASW utilization (with their classification and division based on consumer group and composition).

For the purpose of the challenge implementation it is reasonable to utilize ASW according to the fist point of the classification presented above (ASW transportation into worked-out coal quarry). Besides it is important to take into consideration acute situation with ash dump reservoir filing at some stations. As consequence of that we see an urgent necessity to take measures to utilize big volumes of ASW, which is hardly possible unless the way described above will be brought to life.

The ASW utilization method described above consists of several important stages: cycle of ASW ex-traction from ash dump followed by loading into auto transport, cycle of reloading into railway transport, and also ASW loading point at coal quarry.

Evaluation of this method should be done with attention to one critical part: distance between ash dump to detraining point of railway transport (usually this point placed near a railway station, i.e. place where coal id delivered to), railway distance between station to coal quarry (economical indicators will rise sharply if empty after coal transportation rail cars will be used), and seasonal prevalence (i.e. capability to of ASW shipping in a winter).

In the setting of available information for every station being examined we will be able to calculate cost and liquidity of accumulated ASW transportation. This is a good way to keep region environmental balance because in this case new ash dumps construction is not needed. Therefore there will be no environmental problems and related expenses for a station.

According to the scenario described above we can see that there are two possible ways: either comprehensive utilization of ASW which are located in ash dump, or curtain ASW volume control with cycle productivity variation in terms of surveying ASW volume.

For all new ASM we think it makes sense to divide them into groups in accordance with their application (mostly in construction). In terms of boiler unit load operation it is essential to store them in special places (reservoirs, silos). Several silos will be needed for ash. They should be compatible to product parameters and selling destinations. Slag proposed to be stored in special places in ash dumps; slag shipment to a consumer will be carried out with aid of equipment participated in accumulated ASW extraction.

We offer comprehensive utilization complex of station ASW. This way might become an alternative to new ash dumps building which needs sizable financial investments (according to some evaluation ash dump building costs over one billions of rubles).

It is necessary to mention that most Thermal Power Stations (TPS) were designed without regard to possible industrial use of ASW. That is why they don’t have equipment for ASW transportation and storage, and ash pneumatic conveyor system line up is expensive. Besides, operation of such systems also brings some problems: for instance transportation line sealing happens quite often if pneumatic conveyor system is used for high-free calcium oxide (CaO_{free}), Kansk-Achinsk coal due to CaO_{free} reaction with atmospheric moisture. Ash transportation demands special equipment (cement truck and other). What is more spillage and dusting are impossible to avoid during loading and transportation processes.

Ash packaging in plastic bags is possible to avoid such problems. Ash transportation from boiler shop to packaging shop might be performed with use of some leak-proof tanks or vessels. This scheme has some advantages:

- ability to save some product properties (for instance sorption) by using vacuum packaging;
- scheme simplicity: it is fast and easy to erect, there is no need in additional machinery and pipelines;
- there is no need for special transportation equipment (ash packed in plastic bags might be shipped by regular transport and load-unload by hand).

4 Conclusions

In conclusion it is worth to say that TPS ASW utilization cycles only started to find their application in Russia. Germany on the other hand already utilizes almost 100% of its ASW [6, 7].

Engineering of the utilization process is in need of government legislature support. Existing industry regulatory documents do not provide us with the whole ASW utilization cycle information, and some-times even contradict with each other [7, 8]. Stations which produce ASW also need to make some steps forward because ASW utilization efficiency depends on their policies on the matter. We think that those steps are product certification and marketing research for possible ASM customer acquisition.

Summarize we would like to say that environmental advancement of power industry suggests complex problem solving which includes systematic scientific and technical, technological, standard and methodological and management approach.

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